On the other hand, how interesting it would be to possess a number of such drawings of the same object for all phases of illumination through a whole lunation, or for the same phase in the different degrees of libration!

The principle should always be, to sketch only when the atmosphere is transparent and steady, and then to reproduce everything that is seen within the specified limits with absolute truthfulness. Particular attention will, therefore, have to be paid to the moon in high declinations, and in case the observations are made on the meridian,—which, of course, is the most favorable point,—we must consider the convenience of the draughtsman; and we must either construct the pier of the instrument sufficiently high, or lower the seat of the observer below the floor. Unfortunately, such arrangements cannot be made at Prague.

PRAGUE, April, 1890.

---

REFERENCES TO PROFESSOR WEINEK'S DRAWINGS OF THE MOON.

(SEE FRONTISPIECE.)

No. 1. Mare Crisium.
2. Sinus Iridium.
3. Theopilus, Cyrillus.
4. Gassendi.
5. Columbus, Magellan.
6. Tycho Brahe.
7. Fracastor.
8. Archimides.

---

## ON THE AGE OF PERIODIC COMETS.

BY DANIEL KIRKWOOD, LL. D.

Are periodic comets permanent members of the solar system? Is their relation to the sun co-terminous with that of the planets, or has their origin been more recent, and are they, at least in many instances, liable to dissolution? A consideration of certain facts in connection with these questions will not be without interest.

In the brilliant discussions of LAGRANGE and LAPLACE, demonstrating the stability of the solar system, it was assumed (1), that the planets move in a perfect vacuum; and (2), that they are not subjected to disturbance from without. To these restrictions we may add (3), the implied condition that the analysis does not include all forms of

meteoric, cometic, or asteroidal matter which may exist within the system itself. In these respects their conclusions were not final.

That the interplanetary spaces are filled with an ethereal medium had, indeed, been imagined by different astronomers, but of this theory no mathematical test had been afforded by the facts of observation. ENCKE'S researches on the motion of his comet have been accepted by many as proof that such a medium actually exists. Should this doctrine be confirmed, the consequence would be obvious.

The fate of BIELA'S comet in 1846 directed special attention to cometary physics. Its separation into two parts; the gradual increase of the interval between its members; the return as distinct comets in 1852; the further progress of dissolution beyond the limit of visibility; the resulting star-shower of November 27th—all are now matters of familiar history. Hypotheses, more or less probable, have been offered in explanation, but the significant fact remains—a member of the solar system is lost. How long it had revolved unseen in its eccentric path is unknown, but its history from discovery to dissolution was included in less than one hundred years.

The disappearance of another comet associated with the same cluster has been lately announced. The comet of BRORSEN, discovered in 1846, has a period of about five years and six months. Although its course in 1890 was favorable for its observation, it escaped the most careful search. Should its disappearance prove final, its history as connected with its calculated orbit will comprise but seven perihelion passages.

Twenty-two comets having estimated periods less than that of *Jupiter* have been recorded. Several of these have been seen on but one approach to the sun. Whether the failure of re-detection has been due in any case to a lack of observers, or, as seems not improbable, to perturbation or dissolution, may be a matter of uncertainty. The age of comets—that is, the duration of their visible existence—must depend on their mass and structure, together with their liability to great disturbing influence by the sun and planets. Those with short periods, on account of their frequent subjection to disturbance, will be shorter lived. Those also which are destitute of large or dense nuclei are more easily pulled apart by divellent forces.

"The height of the coma above the nucleus depends on the mass of the nucleus, and gives the measure of its weight, or, more exactly, the least limit of weight which will suffice to maintain such a height of atmosphere.

"The nucleus is usually so closely surrounded by the dense mist

that its diameter cannot be measured; but at times the mist rises, uncovers the nucleus, and leaves it with a sharp stellar aspect. The least diameter determined at such times may be larger than the actual one, but cannot be smaller. From the combination of mass and diameter, the density of the nucleus can be computed. In the case of DONATI'S comet, the diameter of the nucleus was perhaps not more than a hundred miles, while the height of the atmosphere extended to eighteen thousand miles. You may be surprised to learn that the corresponding density of the nucleus was at least equal to that of iron. What an unexpected contrast is here presented to the prevalent notions concerning the sun and the comets! The solid sun is reduced by science to the state of gas, while the substance of the ethereal comet is a solid and heavy metal."*

The doctrine that the integrity of comets may be indefinitely maintained by the attractive force of their nuclei may account for the greater stability of ENCKE'S comet than that of some others. Though the first discovered of the short-period comets, it shows no special symptoms of disintegration. Well-known phenomena, however, undoubtedly indicate that comets, almost without exception, are gradually losing more or less of their mass. Whatever the nature of the process by which the tails are driven off into space, their lost particles can no more be collected around the same nuclei. Moreover, besides BIELA'S comet, already referred to, the initial separation of others, under telescopic view, has been observed by several astronomers. I mention, in particular, the great comet of 1882, whose nucleus, near perihelion, separated into five distinct fragments.

This remarkable comet is perhaps the oldest whose returns are traceable among ancient records.

The orbit is undoubtedly elliptical. The period, according to able computers, is between 700 and 800 years. Dr. MORRISON regards it as identical with the comet 370 B. C.—a comet also reported to have separated into two parts. Its last previous return would thus have occurred in A.D. 1131 or 1132, in each of which years a large comet is recorded. It is a noteworthy fact that this comet belongs to a cluster whose similarity of elements cannot be accidental. Either, therefore, the group existed in space as cosmical clouds before entering the solar system, or we have on a grand scale the partial results of a disintegrating process, the date of whose beginning cannot now be known, but whose continued operation may be traced in the distant future.

* Pierce's Ideality in the Physical Sciences, p. 113.

Is it probable that the number of visible comets within the sun's permanent influence will increase with the age of the system? The fact of frequent cometary dissolutions is no longer doubted, and it is evident that the process, if long continued, must render the original masses invisible, so that in after time the interplanetary spaces must be strewn with dispersed meteoroids. The sporadic meteors now observed in greater or less numbers every clear night may thus be regarded as the scattered debris of ancient comets. If, therefore, we accept LAPLACE'S theory of an extraneous origin, the relative number of comets in the future as compared with the present must depend on the frequency of capture as compared with the rapidity of dissolution.

---

## SOME NOTES ON ASTRONOMY IN SOUTH AMERICA.

BY MILTON UPDEGRAFF.*

Having recently returned from a residence of two years and four months (November, 1887, to March, 1890,) at the National Observatory at Cordoba, Argentine Republic, it is with pleasure that I accept the kind invitation of Professor HOLDEN to write a short outline of my impressions of South American astronomy for the *Publications of the Astronomical Society of the Pacific.* I visited the observatories at La Plata and Santiago, and we intended on our return journey to the United States to visit the observatory at Rio de Janeiro, but circumstances rendered it impossible for us to land there. It is said that a fine observatory is also being built near Quito, within three miles of the equator. This, with what I shall say later concerning improvements at La Plata and Santiago, will show that some of the principal Governments of South America, in proportion to their resources, are spending an unusual amount of money on astronomy.

### CORDOBA.

The National Observatory of the Argentine Republic is so well known in the United States, through the writings of Dr. B. A. GOULD, its founder and until recently its Director, that a few words as to the recent and present work of the institution will be sufficient.

The principal work of this observatory at present is the formation

* Director of the Observatory of the State University, Columbia, Missouri.